the block, for, of course, when the saw goes through a block the surfaces on each side of it must be alike), yet in most cases it is not very difficult to find a series sufficient for the wainscoting of a large room or the top of a long counter which match closely enough for all practical purposes.

While it has been my aim in what has been said of the different varieties mentioned to convey some idea of what they are, it is wholly impossible to place their beauty before the reader. No agate or jasper is more elegant or attractive. Indeed, in looking over slab after slab of the marble I have often been reminded of the close resemblance to agate which the surface before me presented. The Wakefield marble is, much of it, very similar to agate in brilliancy of polish, delicacy of color and general appearance, though quite unlike it in hardness and costliness. Nor do we ever see slabs of agate five or six feet wide and eight or ten feet long, as are some of the slabs of this marble.

——:o:——

A BOTANICAL STUDY OF THE MITE GALL FOUND ON THE BLACK WALNUT.[1]

BY LILLIE J. MARTIN.

DEVOTEES to at least four sciences may do original work on *Erineum anomalum*. Since eggs have been found among the hairs on its surface and neither mycelium nor spores occur in it, it can no longer be ranked among the fungi, and the entomologist alone may study the life-history of its inhabitants. The chemist and physicist will certainly have somewhat to do if they set out to find the forces which are at work in the production of the gall. Nor will the botanist be without employment if he trace its anatomy and full development. This paper is a statement of what was seen in a somewhat superficial botanical examination of the gall during the month of July.

These galls usually occur in the walnut on the under side of the main petiole, somewhat below the first set of leaflets, but are occasionally found somewhat higher up. One or even seven or eight galls may be found on the same petiole (Figs. 1, 2, 3). When but one occurs the petiole is shortened and the leaf is rather smaller than the normal leaf; sometimes the petiole is slightly

[1] Read before the Section of Biology of the American Association for the Advancement of Science in the Philadelphia meeting, 1884.

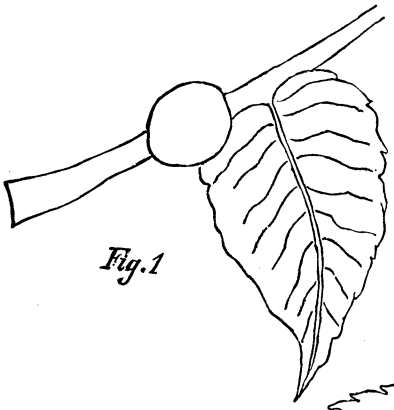


Fig. 1

Fig. 4

Fig. 2

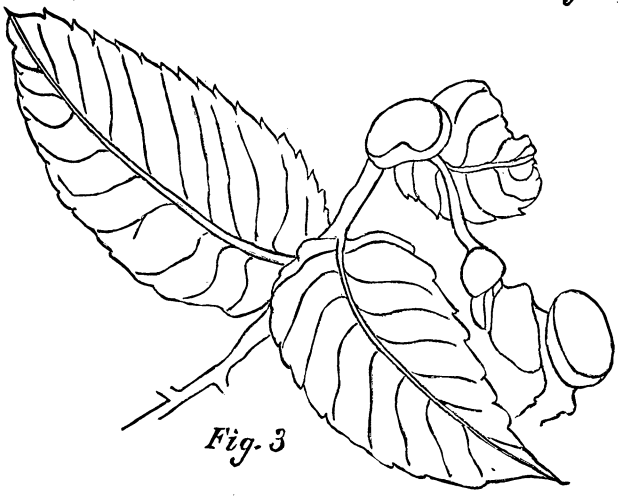


Fig. 3

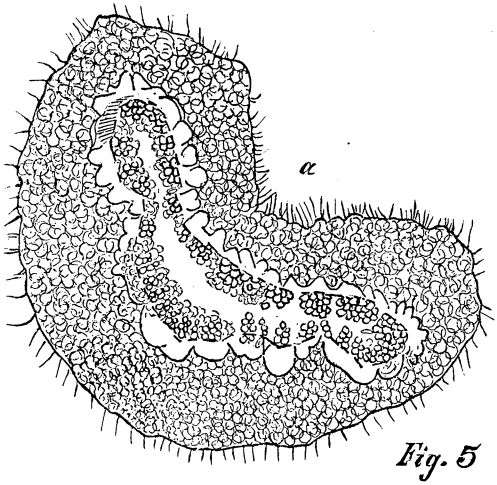
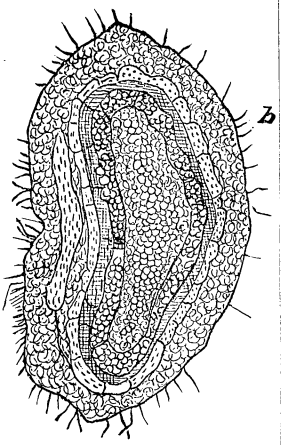
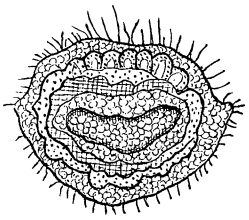


Fig. 5





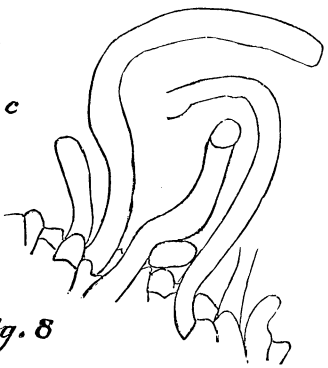


Fig. 8

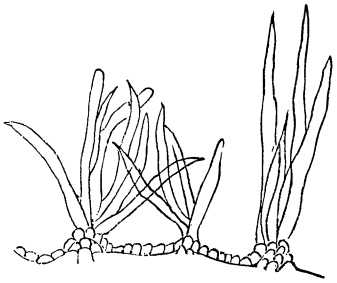


Fig. 6

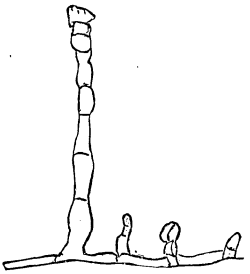


Fig. 7

bent from back to front also. In addition to these changes, when several galls are found on the same petiole (Fig. 3) this is often so much twisted as to bring them on the upper side of the leaf.

The galls are elliptical in shape, the longer axis varying in length from 3^{mm} to 15^{mm} and the shorter from 1^{mm} to 8^{mm}. From above they appear slightly convex; their centers are hairy and purplish-red in color and set in a green ring which is continued below into the petiole. Their average height is about 10^{mm}. In appearance they are not unlike buttons which have their tops mounted in metal holders.

The under surface of the gall is similar in general outline to its upper, as it abruptly contracts before passing into the petiole (Fig. 4), sometimes nearly clasping it either in the direction of its long or short axis. When several galls grow on the same petiole they may either run together or be entirely separate. If they coalesce great changes in size and shape are produced.

The normal petiole is usually horizontal, but sometimes twists the leaf half way round (herbarium specimens). The cross section of the petiole near its base is of a reniform shape on account of a crease in its upper surface. The crease disappears further from the base of the petiole, which then appears elliptical in cross section.

The fibro-vascular bundles of the normal petiole of the walnut are such as are ordinarily found in the stems of dicotyledonous plants. The bundle is better developed as the apex of the petiole is approached. Even here, however, the bast is more abundant than the corresponding wood. An examination of that part of the petiole where the crease has disappeared shows a second row of well developed fibro-vascular bundles. Almost no trace of this can be seen in the lower part of the petiole (Fig. 5).

Under a low power of the microscope a longitudinal radial section of that part of the gall near the pith of the petiole resembles a drawing of a geological section of the earth in which the strata are very much bent and folded (Fig. 10). The cells themselves are bent, but the folding takes place mainly between contiguous cells. In comparing cross and longitudinal-radial sections of the gall (Figs. 9 and 10) the bast is found to be quite as abundant as in the normal petiole, but is spread over a wider area. The wood, too, is as scanty as before. The tracheary vessels have almost entirely disappeared. Tracheids have not only

supplied their place but mainly compose that part of the gall that is made up of folded tissue. Two or three layers of the pitted cells near the pith are wider than long and regular in shape.

As the distance from the pith increases the cells increase in length and decrease in breadth until they are two or three times longer than broad. Owing to the crowding to which they are exposed, they become irregular in shape nearer the surface of the fibro-vascular bundle.

In the normal petiole the cells overlying the fibro-vascular bundle are longer than broad, regular in shape and contain but little protoplasm. The corresponding part in the galls is made up of much larger cells, irregular in form and filled with a granular substance which is slightly colored yellow by iodine, and red by eosin.

Clustered and glandular hairs are found irregularly distributed over the petiole. The clustered hairs (Fig. 6) are found abundantly on the upper side of the petiole near its base. From this point their number decreases though there are still more on the upper side of the petiole than on the lower. They originate from cells of the epidermis which have crowded together in papilla-like masses. But one hair arises from each cell. Each papilla may have but one hair, though it will often have nine or ten. The ordinary number is five or six. The hairs themselves are one-celled and pointed toward the apex. At the extremity their walls are so thickened as to nearly obliterate the cavity. They are thinner towards the base, and iodine shows protoplasm to be present.

The glandular hairs vary in shape. In a general way they are made up of several cells, the terminal cell being larger than those below, and secreting an "acrid aromatic" substance. Iodine shows that there is protoplasm in their cells. These glandular hairs arise from single epidermal cells which are separate from each other by two or three intervening cells.

The galls have no differentiated epidermis. Certain cells which from their position would be called epidermal are without protoplasm, but in other respects resemble those beneath. From nearly every one of the epidermal cells cylindrical, one-celled hairs arise (Fig. 8). These hairs seem to be a continuation of the epidermis. They are about 1^{mm} in length and $\frac{1}{20}$ mm in diameter, that is, at least twice as long and broad as the normal hairs.

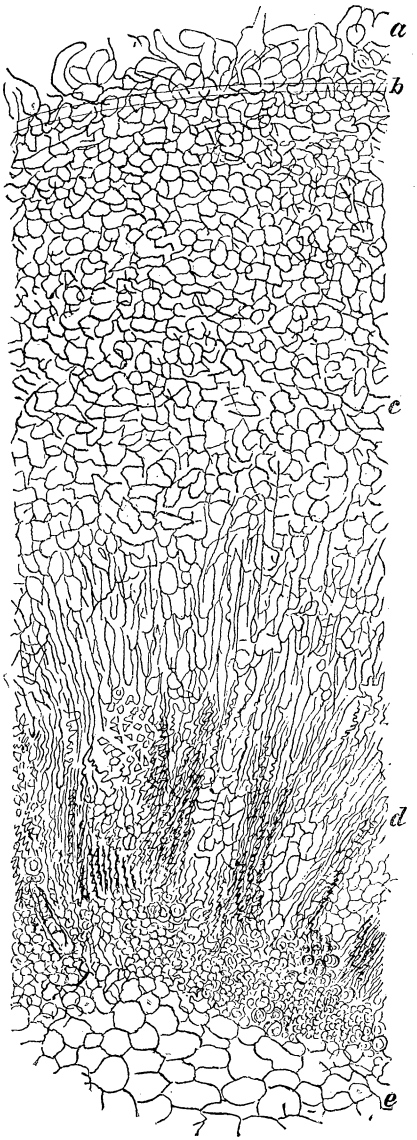


Fig. 9

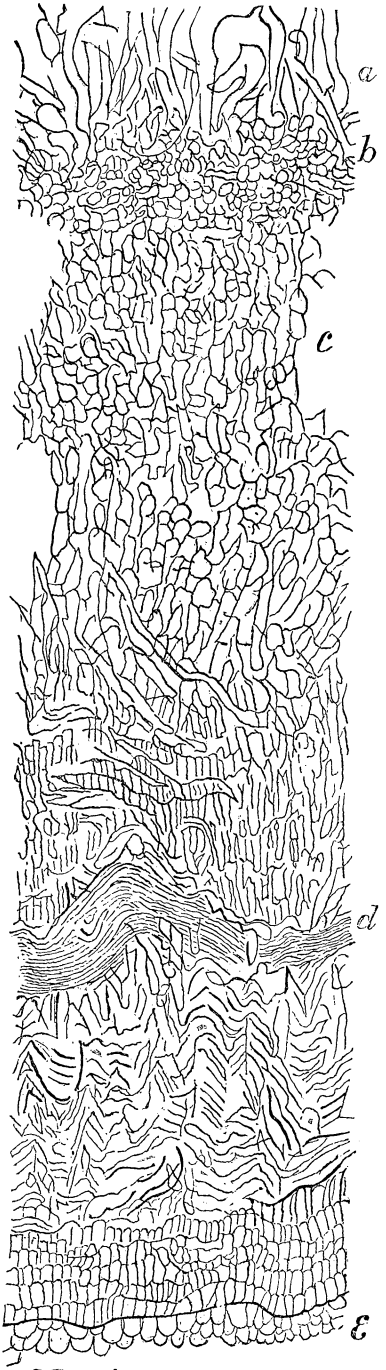


Fig. 10.

These cells contain a purplish-red coloring matter which is soluble in water. If this is removed the cells are found to contain a large quantity of a brown granular substance. The hairs of the gall are so unlike normal hairs in shape, position, contents and origin that they can scarcely be looked upon as modified trichomes. Ensconced among the hairs which are distributed over the surface of the gall are found the eggs of the mite which produces it.

In order to know the changes which the gall has undergone in reaching its mature state, it would be necessary to make a careful study of the specimens of the gall from its first appearance to its full development. I hope to do this in the future. Possibly it may not be too presumptuous to venture a few predictions founded on a comparison of the gall with the normal petiole in regard to development:

1. The gall must have started very early. The fact that the gall hairs cannot be looked upon as modified trichomes has been already referred to. Vestiges of the normal trichomes would be found among the gall hairs if the petiole had been far enough advanced for them to appear, but no such remains are found. The epidermal cells of the gall are so thin-walled and so unlike the thick-walled and regular epidermal cells of the petiole in form, that they could have originated from them only at an early period. Comparison of the tissue beneath the epidermis in the gall and petiole does not suggest that one was derived from the other.

2. The development was doubtless inward, the stimulant, no matter of what nature, acting on the outside. The position of the eggs, the mode of oviposition of mites and the fact that no sign of their having pierced the tissue can be found, suggests this. The bending and folding of the fibro-vascular tissue would seem to suggest that the stimulant caused a greater growth in length than in breadth, and this produced the lateral pressure which pushed up the tissue.

3. The value of these various modifications to the mite may be seen in a general way. The hairs of the gall give the very best protection to the eggs, the parenchyma is an excellent cushion and is firmly supported by the tracheids which, with the other

portions of the fibro-vascular systems may also serve their usual purpose of conductors of water.

EXPLANATION OF PLATES.

PLATE IV.

FIG. 1.—Sketch of a gall showing its ordinary form, size and position. Natural size.

FIG. 2.—Sketch of the gall showing its appearance when found above the first set of leaflets.

FIG. 3.—Several galls on the same petiole showing the effect on stem and the general arrangement and shape of the galls when more than one occurs on the same petiole.

FIG. 4.—Cross section of gall and petiole, showing internal appearance of gall.

PLATE V.

FIG. 5.—Cross sections of normal petiole; *a*, at base, no well-developed second row of fibro-vascular bundles; *b*, below first pair of leaflets, appearance of second row of fibro-vascular bundles; *c*, above first pair of leaflets, a well-developed second row of fibro-vascular bundles. × 25.

FIG. 6.—Clustered hairs. × 165.

FIG. 7.—Glandular hairs. × 165.

FIG. 8.—Gall hairs, extensions of epidermal cells.

PLATE VI.

FIG. 9.—Cross section of petiole and gall; *a*, gall hairs which appear to be continuations of the epidermis *b*; *c*, parenchyma beneath the epidermis; *d*, fibro-vascular bundles in which tracheids have supplied the place of tracheary and other vessels; *e*, parenchyma of the pith (highly magnified).

FIG. 10.—Longitudinal-radial section of petiole and gall; *a*, *b*, *c*, *d*, *e*, as in fig. 9 (highly magnified).

——:o:——

ON THE EVOLUTION OF THE VERTEBRATA, PROGRESSIVE AND RETROGRESSIVE.

BY E. D. COPE.

I. PRELIMINARY.

IN attempting to ascertain the course of evolution of the Vertebrata, and to construct phylogenetic diagrams which shall express this history, among the difficulties arising from deficient information, one is especially prominent. As is well known, there are many types in all the orders of the Vertebrata which present us with rudimentary organs, as rudimental digits, feet or limbs, rudimental fins, teeth and wings. There is scarcely an organ or part which is not somewhere in a rudimental and more or less useless condition. The difficulty which these cases present is, simply, whether they be persistent primitive conditions, to